
OUTCOMES IN GENERAL CHEMISTRY

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In coming to this Symposium from the research laboratory of a chemical company, I feel that I am obliged to present my credentials before speaking on the subject of outcomes in general chemistry. I do this at the risk of appearing to indulge in self-aggrandizement; but I shall take this risk since you will need to know what sustains my confidence in addressing myself to the topic.

As far as teaching is concerned you should know that I taught general chemistry at Yale for six years and that during this period of time something of the order of 300 freshmen sat in my classroom. Most of you are aware that in the past Yale has used the small section technique involving 20-25 students per class. During this period I was associated with upwards of twenty instructors who were also teaching on the freshman level, and I also had the opportunity of working with Professor Stuart R. Brinkley, a man of infinite patience and wisdom, who was in charge of the Freshman Year in Chemistry at Yale. I also taught organic chemistry to juniors, organic chemical theory and research techniques in the laboratory to graduate students, and had a dozen doctoral students in research in this period. So, what I lack in length in academic experience is in part made up by having run the gamut of teaching at both the college and university levels. The critique system in force at Yale proved invaluable to the instructors and certainly helped us correct annoying and distracting habits of which we were unaware. Under this system the freshmen at the end of the year were permitted to write down, in camera, precisely what their opinion of you as a teacher happened to be and then compared you with other instructors they had had. This could be both brutal and enlightening. In my experience none of the full professors were anxious to extend this practice past the first year students. But we of younger years profited greatly by it.

In 1955 I left Yale as part of an experiment dealing with the question of whether or not a basic research group can conduct free and unfettered research in an industrial atmosphere. However, this experiment is not the subject of my discussion here, but it is part of the background from which I shall draw. Another piece of background is my acquaintance with men who are undoubtedly leaders in our science and who are superb examples of creative, independent individuals of science. I speak of such men as Onsager, Kirkwood, Fuoss, and Doering of Yale; Kistiakowsky, Bartlett, and Woodward of Harvard; Pauling and Roberts of Caltech; Winstein and Cram of U. C. L. A., and others. I mention these men because I have made an attempt to observe them closely and have tried to see what makes them creative and useful in the science.

Before entering the main body of this discussion I wish to make also several cautionary remarks. Some of my statements will be severely critical, and I

want you to remember that these remarks as well as others are not based solely upon my experiences at Yale but also on my undergraduate years at Indiana, graduate years at Columbia and the year of work in German laboratories prior to the last war. In the same vein my industrial experiences are based upon contacts with Hercules, duPont, Union Carbide, G. D. Searle of Chicago, and several other smaller companies with whom I have been associated in the past. I'd like to proceed then with these points in mind.

First of all, let's talk about the first year of college and its effect upon the rest of the student's life. This morning Professor Steiner told you a great deal about the care and propagation of a superior student. This afternoon I want to tell you about the care and propagation of a mediocre student. I think that the figures are on my side and so let's see how you turn out a mediocre academic product. By "mediocre," according to Webster, one means "moderate" or "ordinary" but not "average." Educators don't know what an average student is and I don't either. So let's take a hypothetical student and march him off to college and let's further hypothesize that he's not been hopelessly maimed by his elementary and/or secondary education, and that he still retains a part of the natural curiosity and power of concentration with which every normal child is endowed and which become severely attenuated by the time he reaches college. Let me show you now how you may kill the last traces of these scholarly attributes.

We must look first at the college and ask if there is an atmosphere of scholarship—a tradition of intellectual achievement. There are some very fine schools in this country and I am proud to say that Ohio has its share of them; but there are also others, even some with heavily ivied walls, in which these traditions do not exist in spite of the lip service paid to them. Our freshman will discover this quickly, for he is at an impressionistic age and will emulate the upperclassmen almost immediately. In a college where scholarship is a lost cause, he will have learned to drift vigorously by the end of the first semester. Under such conditions we may easily understand what G. B. Shaw meant when he said that his education had been interrupted by his schooling. Of course, the atmosphere of a college is an ephemeral thing and certainly something which requires a number of years to change or create. And when we talk of a college, we are talking of its faculty, for it is the faculty which makes the college.

Our young man from high school, or prep school, meets his faculty and experiences his first collegiate emotional encounter. This adolescent is quite sensitive and is already under considerable strain from his transition from home to a new independence. And so what he finds in his instructors will have a profoundly subtle and intimate effect upon him. You are acutely aware in some instances of the emotional upsets which the student encounters. Now what does our student find in his instructor? A man who is tired, disillusioned, and disgruntled? But why tired? After teaching the same course for thirty years, why not tired? After reflecting on a number of ambitions unrealized in his science because of the press of his teaching duties, why should he not become disillusioned? And after a life of economic frustration, why not disgruntled? This man finds himself facing another year of teaching in the same course with the same old notes and in the same old rut. This is the man and instructor which our impressionable first year student encounters. The effect will of course be obvious and permanent. I strongly suspect that all of us can easily conjure forth the image of teachers who fit this description.

It is an unfortunate matter that in many of our colleges it is seen fit to entrust the education of the freshman to the "driftwood" and the inexperienced. And yet this is the level where the best teaching efforts should be made. It has been said that freshmen teaching is a fine place in which to break in the new instructors. Undoubtedly—and break the student too! By and large, the older faculty avoid the first year teaching loads like poison for the simple reason that this is one of

the hardest jobs available. I personally would rate it as the toughest one I've ever had and I include steel mills in my working experiences.

Quite recently, by way of illustration, the head of the chemistry department of a small but quite well-known eastern college offered one of my former doctoral students the post of assistant professor and the responsibility of reorganizing the freshmen program. This young man had had no teaching experience and in fact had been in chemical industry for several years but was anxious to enter the academic field. However, he didn't bargain for these terms and very wisely rejected this form of career suicide. The point is, however, that the chairman of this department was willing to turn over this course to a young, untried man. The whole situation is turned around. The first year courses are for men who are seasoned and who have demonstrated an ability to inspire and to create enthusiasm in the new college student. This is the place and the time at which our student is subject to hero-worship. We must make sure that he has a hero to look up to and to emulate. A fine teacher invariably will be found to be active in other areas of his science too, for this is a part of excellence. He will be publishing, writing, reading, and keeping alive in his field. You'll not find him devoted exclusively to the next selection of the Book-of-the-Month Club outside of the classroom.

I'd like to say a bit about the classroom which has been aptly described as the seminar of the mind. First, I would wish to eliminate the carnival or sideshow performances often called lecture demonstrations. This to me is a diversion and not an effective technique in teaching. This is not to say that an occasional single experiment which is both crucial and germane to the subject at hand is not valuable; but a common indulgence in pyrotechnics is not only an evasion of teaching, it can and has led to the near annihilation, physical and mental, of freshmen in some instances. Instead, I would ask that in the classroom more emphasis be placed on reasoning and precision of thought. A number of my students, for example, were considerably shaken by the fact that a cubic centimeter is not equivalent to a milliliter and thought this difference to be trivial. It is true that the difference is small, but it is not trivial. Education which involves teaching inaccuracies such as the placing of electron orbits around a nucleus in the shape of a bull's eye is both shoddy and grossly misleading. It's true that many such ideas have to be taught initially in a qualitative manner. However, a qualitative matter and an inaccurate matter are two widely different things. Thus, shoddy reasoning, lack of precision in thought, and the teaching of inaccuracies will surely propagate a mediocre student.

The matter of getting through to the student in the classroom deserves some mention here. Jacques Barzun at Columbia expressed himself quite well on this problem when he spoke of teaching on the undergraduate level as being comparable to conducting a long distance telephone conversation to Cleveland in the middle of a cocktail party. By and large the easy way out is to simply get on with your lecture and let the words fall where they may, or you may attempt to get through by boxing the compass. By this I mean making as wide a range of appeal as you possibly can. As an example, I recall lecturing solidly for one hour on the subject of Pip in Dicken's "Great Expectations" in an effort to salvage a particularly recalcitrant English major. This maneuver was both surprising to the students and successful, for I got to this boy and secured his subsequent interest in the more germane aspects of the course. On the other hand I worry that I may have lost several chemistry majors in the process.

Professor Steiner spoke of the importance of the laboratory in the teaching of general chemistry. I should like to enter a very hearty second to this. If the classroom is the seminar of the mind, then the laboratory must be the seminar of the hands, of the experimental method, of the scientific technique. I would be perfectly willing, however, to see all the set experiments, such as the bubbling

of oxygen under water into those confounded inverted jars, go. The laboratory should become the center of the truly personal project. This is the place where the emphasis should be placed on letting the individual do his own work at his own pace. In fact, it is in the laboratory that the primary purpose of education can be most effectively achieved by training the student to educate himself.

In summation I wish to make several constructive remarks after some of the destructive ones I have given. I would suggest that we have less circus and more substance in the classroom; that more emphasis be placed on a seminar type of discussion at the expense of strictly formal lecturing; that all deans who insist on curve grading be boiled in oil; and that we demand more performance on the part of the student even at the expense of extracurricular activities. In the latter connection I denounce as doggerel those lines which give the impression that Britain's battles are won on the playing fields of Eton. This is an insult to the faculty of that venerable institution. I would suggest that we abolish all forms of spoon feeding and that the student be made responsible for his own academic progress. This, in my opinion, is one of the more attractive corner stones of the European educational system which has been neglected in ours. I would suggest that the laboratory be made the focus of special project work and the source of the development of scientific enthusiasm for the student.

With respect to able teachers of the subject of general chemistry, I would say that when you find one, surround him with assistants, take the paper work away from his desk, plaster him with Cadillacs and even import a harem if this is required to keep him happy. At all costs allow him freedom to teach. College offices must be transformed into business offices if they are to eliminate the inefficiency and waste of valuable time which impede the academician.

In conclusion I shall make the observation that a drastic improvement of the standards of first year teaching in the colleges will enforce the improvement of the curricula and standards of our high schools. The high schools will have to follow. This seems to me to be the only intelligent way in which to improve our educational system.
